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# Solving Electricity Deficit in Kinshasa With Solar Kits

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This paper highlights the importance of adopting use of solar kits to overcome the shortage of electricity supply in the city of Kinshasa instead of polluting generators. Given a need for electricity delivery estimated at 5 kWh for a poor household of three occupants, a 1 kW solar kit sold for US $990 would perfectly replace SNEL network, the unique electric utility company that uses rolling blackout to handle its low power supply capability within the town, with all the environmental benefits in lieu of a 4 kW power generator sold at US $900 with all the consequences related to the use of fossil fuels in terms of $CO_2$ emissions harmful to health and the environment. Similarly for a middle class household of five occupants, a solar kit of 3 kW to 2,700 dollars or 5 kW to 4,600 dollars is far preferable to an 8 kW generator of US $4,155 which pollutes and entails expenses related to the fuel consumption.

*Keywords:* power generator, load shedding or rolling blackout, solar kit

## Introduction

A nation's energy resources contribute fully to its economic growth through the achievements they make possible. Energy is important for all sectors of the economy; the mastery of energy is the motor of human activity (University of Colorado, 2006). All forms of energy can be transformed into electrical energy for the development of industrial, commercial, and agricultural activities as well as essential social services such as education and health (Evans, 2007). However, despite its energy potential (Uranium, Coal, Oil, Congo River, etc.), the DRCongo has a huge energy deficit. Though its substantial hydroelectric resources estimated at around 100,000 MW (ANAPI, 2016), the country has not be able to take full profit of this potential to provide most of the energy needed to operate businesses, supply transportation, and provide comfortable living ... Its energy deficit is reflected today in a low rate of service in electricity estimated at only 9% for a population of nearly 80 million inhabitants. Many households in rural areas are still dependent on solid fuels for cooking, heating and have no access to electricity. And even those who have access to electricity, they constantly face the problem of rotational load shedding, which means a partial distribution in electricity. Households are often deprived temporarily of power for 24, 48, or 72 hours. Due to this situation, Congolese invent new forms of social organization through acquisition of generators to, at least, iron, watch TV in the evening and especially turn on lights when it is dark. Cooking is provided by a charcoal industry commonly called "makala" preferred over oil and gas for its relatively low cost. The poorest people, who cannot afford charcoal, are content with less common sources of energy such as sawdust. This survival behavior, a portrait of widespread poverty, is far

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from relieving the population because it has very negative environmental consequences. Thus, through this paper, we analyze the possibility of initiating other energy alternatives for this country and specially its capital Kinshasa, such as solar energy with all its advantages in terms of cost, installation, and protection of the environment.

## Data and Methodology

The data used in this paper come from periodicals, newspapers, and specialized books on energy. We also proceeded to a field research to retrieve raw data that we exploited and oriented in the direction of our analysis. An analytical and comparative method is then used to evaluate electricity supply and demand in the city of Kinshasa and thus propose more practical solutions in terms of solar energy.

## Estimation of Households' Electricity Demand in the City of Kinshasa

### Demographic Evolution of the City

The city of Kinshasa shows a strong demographic evolution accentuated by an influx of war refugees and an ever increasing urbanization. The demand for electricity would have quadrupled in 10 years following this booming population shown in the graph below.

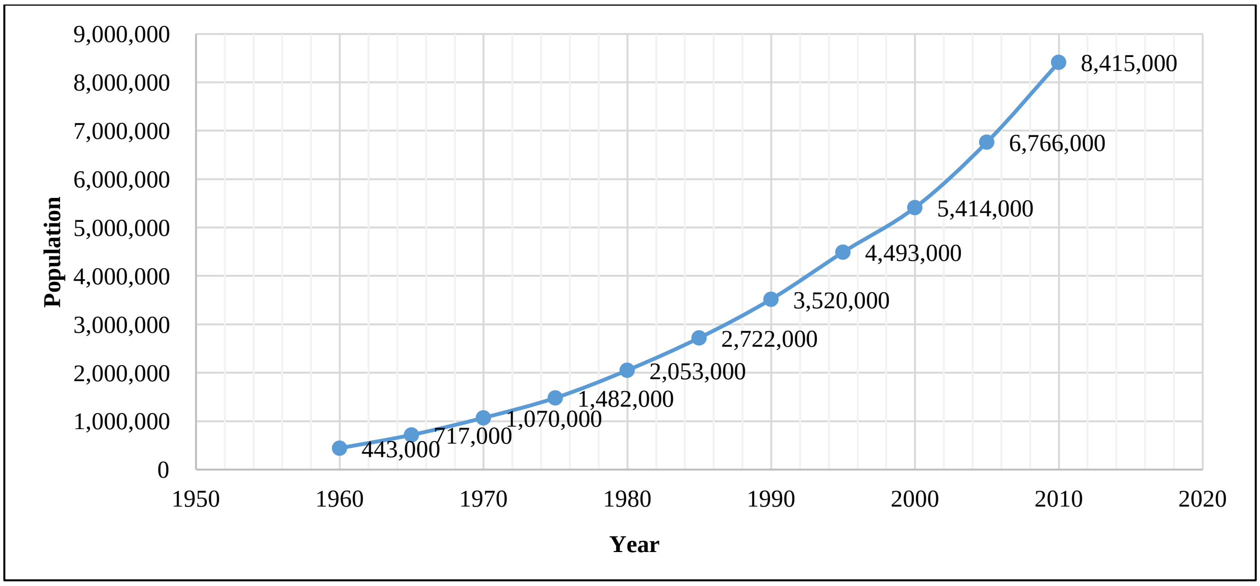


*Figure 1.* Demographic evolution of Kinshasa population. Source: Data from World Development Indicators 2017.

This population growth reflects ever-increasing energy needs. The chart starting from 1960, the year of independence, reveals the challenges facing the country in terms of energy needs to cover.

### Household Demand for Electricity (Ang, 1986)

To understand the household need for electricity, a practical method much more realistic prevailed over the ones used in many literatures that only take statistics on the electricity production divided by the population. Our main goal being to estimate the real need in terms of electrical consumption that is a function of the occupied surface, the number of rooms to be lit, appliances available, living habits of the occupants, we have targeted three types of households for the city of Kinshasa: poor households, middle class households, and rich households. In this paper, the estimate is made only for poor and middle class household.

**Assumptions.** The identification of the type of household is based on the wealth in possession at home, the area occupied by inhabitants as well as the number of adult occupants. Rather than referring to income, which is a non-existent variable in the Congo, material possession seemed more convenient to determine the electricity needs of a household, which, moreover, depends on the size of the house, the number of occupants, the number of rooms to be enlighten, the cooking system (charcoal or electric), the domestic hot water production system (electric stove, electric water heater, or gas stove ...), and finally the number of appliances and their energy label. It is also necessary to add the lifestyle of the occupants of the dwelling and their consumption habits. Indeed, a person staying at home most of the time will consume more energy than a person who is regularly absent.

**Poor household.** We consider as a poor household, a family of three adults occupying a three-room residence with a TV set, an iron, a fan, a radio, and three phones. From these assets, below is an estimate of the electricity consumption (Moller Andersen, Baldini, Hansen, & Jensen, 2017).

- Appliances
- 1 CRT television: 120 w x 15 h = 1,800 w = 1.8 kWh
- 1 iron: 750 w x 1 h = 750 w = 0.75 kWh
- 1 fan: 45 w x 6 h = 270 w = 0.27 kWh
- 1 radio: 6 w x 18 h = 108 w = 0.108 kWh
- Lighting
- 3 bulbs: 2 bulbs of 75 w x 8 h = 1,200 w = 1.2 kWh
- 1 bulb of 100 w x 12 h = 1,200 w = 1.2 kWh

Total: 5.358 kWh

**Middle class household.** This is for us, a family of five adults occupying a residence of more or less six rooms and having two televisions, an iron, a refrigerator, a radio, an air conditioner, a fan, a laptop, and 10 phones.

- Appliances
- 2 televisions: 1 LCD 200 w x 14 h = 2,800 w = 2.8 kWh
- 1 CRT television: 120 w x 3 h = 360 w = 0.36 kWh
- 1 refrigerator: 500 w x 24 h = 12,000 w = 12 kWh
- 1 iron: 750 w x 2 h = 1,500 w = 1.5 kWh
- 10 cellphones: (10 x 5 w) x 2 h = 0.1 kWh
- 1 laptop: 80 w x 2 h = 160 w = 0.16 kWh
- 1 radio: 6 w x 6 h = 36 w = 0.036 kWh
- 1 cooker: 1,800 w x 3 h = 5,400 w = 5.4 kWh
- 1 split: 12,000 BTU = 3,500 w x 4 h = 14,000 w = 14 kWh
- 1 fan: 45 w x 4 h = 180 w = 0.18 kWh
- Lighting
- 1 Chandelier (6): 360 w x 4 h = 1,440 w = 1.44 kWh
- Interior lights (6): 360 w x 6 h = 2,160 w = 2.16 kWh
- Exterior light (4): 400 w x 12 h = 4,800 w = 4.80 kWh

Total: 44,936 kWh

From these assumptions, an estimate of about 5 kWh for a poor household and 45 kWh for a middle class household is evaluated in terms of electricity consumption. An alternative approach of electricity demand per capita according to each social rank will end up with 1.786 kWh/inhabitant for a poor household and 8.9872 kWh/inhabitant for a middle-class household. For lighting only our two households need 2.4 kWh and 8.40 kWh respectively. The basic need for lighting, fan leads the choice for generators as alternatives to the production of electricity.

**Household Electricity Supply**

The electricity supply in Kinshasa is a task devoted to SNEL, a public national company. Due to poor management, this company fails in production and delivery of electricity. This company currently operates only 480 megawatts to meet the need of this city of 8-10 million inhabitants. A simple computing applying electrical distribution rules, taking into account the efficiency of 0.8, the available megawatt electric (MWe) capacity would be of 384 as explained in the table below.

Table 1

*Kinshasa Power Supply*

| | | Power |
|---|---|---|
| Power, MW | | 480.00 |
| Efficiency | 0.80 | |
| Power MWe | | 384 |
| Hours par an | 8,760 | |
| Energy, E = MWh | | 3,363,840.00 |
| 1 MWh = y kWh | 1,000 | |
| E, KWeh | | 3,363,840,000.00 |

Source: Made from Snel General Manager Statement.

From 384 MWe, the real efficiency obtained, taking into account losses due to transport and distribution, an estimate of the real offer is of 3,363,840,000.00. This capacity represents an average per capita electricity consumption of 336.384 kWh or 420.48 kWh/inhab. depending on whether the population is estimated at 10 or 8 million. This annual electricity consumption gives us daily figures of 0.93 kWh/person/day or 1.1 kWh/person/day depending on whether we are 8 or 10 million inhabitants. An obvious deficit is in the supply of electricity. This lower power supply capability is recognized by the head of SNEL and justified by a poor production, transmission, and distribution infrastructure of management in electrical energy. Consequently rolling blackout or rotational load shedding every day is the last-resort measure used to fill the power gap in all municipalities of the capital.

To face with this situation, adaptation behaviors have been developed, ranging from the use of gas, charcoal, and use of an electric generator to overcome the need for electricity without integrating the environmental aspects of these electricity sources alternatives. The next paragraph highlights some aspects related to the use of generators as energy alternatives.

**Generators alternatives.**

a. Generator description (Gill, 2016)

A generator is an autonomous device capable of generating electricity. Generators are used either in the areas where electricity delivery is stopped for non-overlapping periods of time over different parts of the distribution region, or to alleviate a possible power failure, or as a complement to an uninterrupted power supply consisting of a storage battery that powers a power supply. The power of a generator is expressed in KVA (kilo volt amps). They work from all fuels. The most common are gasoline, diesel, natural gas, LPG, biofuels, and the most powerful heavy fuel oil. However, the models commonly used in the Congo, mostly coming from China, Dubai, or Lebanon, run on gasoline and diesel.

b. Cost of generator acquisition

Table 2

*Price for Generators in Kinshasa Market*

| Rated output/max output KW | KVA | Price ($) |
|---|---|---|
| 2.24 | 2.8 | 360 |
| 2.8 | 3.5 | 400 |
| 4 | 5 | 900 |
| 4.4 | 5.5 (silent) | 1,450 |
| 4.8 | 6 (silent) | 1,580 |
| 5.2 | 6.5 | 840 |
| 8 | 10 | 4,155 |
| 8 | 10 (silent) | 5,000 |
| 12 | 15 (silent) | 13,500 |

Source: Jehovah jireh shop, Id. Nat. 01-929-N766986W.

Gasoline as well as fuel oil, main source of electricity generation in power generators is polluting. It is necessary at this time of green initiative to inspire awareness by calculating the $CO_2$ emissions according to the amount of fuel consumed to take into account externalities to be incorporated into the real cost of this alternative.

c. Operating cost

- Diesel

One liter of diesel weighs 835 grams. Diesel is 86.2% carbon (C), which corresponds to 720 g of C per liter of diesel. To burn this C in $CO_2$, 1,920 g of oxygen is needed. The sum therefore gives us 720 + 1,920 = 2,640 g of CO2 per liter of diesel.

Table 3

*Operating Costs Related to Diesel Generator*

| Power (kWh) | Consumption (l) | Emissions (kg $CO_2$) | Cost of diesel ($) |
|---|---|---|---|
| 2.5 | 0.2328 | 0.2699 | 0.28 |
| 5 | 0.4655 | 1.3495 | 0.57 |
| 7 | 0.6517 | 1.8893 | 0.80 |
| 10 | 0.931 | 2.699 | 1.15 |
| 45 | 4.1895 | 12.14 | 5.16 |

*Note.* *1l of diesel for 1,970 FC = 1.23US $. Source: Inspired from data collected from the field.

- Gasoline

One liter of gasoline weighs 750 grams. Gasoline is 87% carbon (C), which corresponds to 652 g of C per liter of gasoline. To burn this C in $CO_2$, 1,740 g of oxygen are necessary. The sum therefore gives us 652 + 1,740 = 2,392 g of $CO_2$ per liter of gasoline.

Table 4

*Operating Costs Related to Diesel Generator*

| Power (kWh) | Consumption (l) | Emissions (kg $CO_2$) | Cost of gasoline ($) |
|---|---|---|---|
| 2.5 | 0.2595 | 0.66 | 0.32 |
| 5 | 0.519 | 1.32 | 0.64 |
| 7 | 0.7266 | 1.848 | 0.9 |
| 10 | 1.038 | 2.64 | 1.28 |
| 45 | 4.671 | 11.88 | 5.78 |

*Note.* *1l of gasoline for 1,980 FC = 1.24US $.

The use of generators as an alternative to electricity generation leads to a fuel consumption and an estimate of $CO_2$ emissions evaluated through the table above.

For a 5 kWh need, a poor family would pay more or less of 900 US dollars for the acquisition and a little less than a dollar for the fuel supply.

For 45 kWh need, a middle-class family would pay more than $4,155 for the acquisition and almost US $6 for the fuel supply.

The evaluation of the costs involved should not however end at the cost of acquisition and the operating cost. It is imperative to integrate other costs.

d. Environmental cost of current energy alternatives (Bontems & Rotillon, 2013)

Generators produce carbon dioxide, an asphyxiating gas, as well as carbon monoxide, extremely toxic and more or less undetectable. Even in good condition and placed in an airy room like a garage, but adjoining a part of occupied housing, they can be the cause of fatal intoxications. The generator user is exposed daily to intoxication by the fact that he uses public transport during the day time for his daily activity exposing himself to the $CO_2$ released by an obsolete transport system and on his return home, he still aspire emissions from his own generator

The coal industry is not without danger; it causes deforestation and the scarcity of wood resources (Rapp, 2010, p. 96). The smoke caused by wood for cooking is very polluting and causes many diseases. The fuels used for lamps at night causes a black smoke harmful to health. The use of a renewable energy source such as solar energy can help solve these problems. And in this area, the Congo has considerable assets.

**Solar kit alternatives.**

***Solar potential in Congo.*** The Democratic Republic of Congo is in a very high band of sunshine whose values are between 3,250 and 6,000 Watt peak/m$^2$/J for solar energy. Kinshasa the capital also has a considerable solar potential; the average sunshine varies between 3.22 and 4.89 kWh/m$^2$/d, values well above the PACA acronym for the Provence-Alpes-Côte d'Azur region in France, which is considered as a region characterized by excellent sunshine with an irradiation of 3 kWh/m², the first French solar region in terms of power connected to the grid. Note that under standard solar conditions, the maximum power of a cell when the sky is clear, is 1,000 W/m², at a temperature of 25 °C and a standardization of the spectrum of light AM 1.5 (atmospheric mass). With this potentiality, the country can take advantage of photovoltaic electricity applications.

***Photovoltaic electricity (Aantony, Durschner, & Remmers, 2006, p. 58).*** The sun's rays can be transformed through solar cells to produce electricity. This is what we call photovoltaic energy. A solar cell is an electronic component that, exposed to light, produces electricity. It consists of a thin silicon wafer with a thickness between 0.2 and 0.3 mm, called “wafer”. The set of solar cells connected in series constitutes a module. And several modules connected in series constitute a photovoltaic installation otherwise called solar photovoltaic panel. A photovoltaic power plant is therefore the set of several photovoltaic installations. For domestic use, useful applications are lighting, cold (refrigerator, air conditioning, etc.), water supply, and communication (radio, TV, telephone, etc.). The amount of sunshine striking the surface our planet annually provides more than 10,000 times the amount of energy that all of humanity can use in a year

***Solar kit.*** For individual photovoltaic project, two installation systems can be built. An installation connected to the network and a stand-alone installation. In the case of an installation connected to the network, sizing can be done in different ways. The three most used criteria are: electricity consumption, available space, and budget.

Four elements are important to set up the solar kit (Tianjin Hanteng Energy Saving Equipment Co. Ltd).

a. Solar panels also called photovoltaic modules, which convert light into electricity.

b. Batteries: provide energy storage to run the system when there is no sun. Its other role is to power devices more powerful than the cumulative panels.

c. The regulator or solar charger: Its role is to stop the charge of the battery when it is already fully charged and thus avoid overcharging.

d. The inverter: It plays the role of converter; it is a power electronics device for converting the direct current received from the panels in alternating current

Table 5

*Preferential Price of Solar Kits in Kinshasa*

| Power (kW) | Price (US $) |
|---|---|
| 1 | 990 |
| 3 | 2,700 |
| 5 | 4,600 |
| 8 | 7,500 |
| 10 | 9,800 |

Source: SOLARANDU STD LTD.

Prices may vary according to several criteria for the same desired power. For our analysis, our choice is based on SOLARANDU’s company offer.

A poor family or household can meet his electricity need with a 1 kW solar kit for 900 dollars that can power the lighting, television, and even a small refrigerator (100-120 w). A middle class household would end up with a 3 kW solar kit of 2,700 dollars that would support the light, television, refrigerator, and even a split. A capacity of 5 kW solar kit would be well within the reach of a wealthy family. The next paper will address this issue.

An annual assessment of the two alternatives as response to electricity deficit in Kinshasa reveals the supremacy of the solar kits on generators currently in vogue on the Kinshasa market. Results have estimated that a poor family would cover their electricity needs with a 5 KVA generator, which translates to an acquisition cost of $900. The operating cost expressed through fuel consumption is $230 a year. The total annual cost without taking into account the cost of maintenance of the machine and the cost of externalities that could not be less because of pollution not limited to the user but has the whole neighborhood, is 1,130 dollars.

On the other hand with 990 dollars disbursed for an autonomous solar system, a poor family ensures its comfort of electricity supply and cannot envisage other relative expenses only after three years for replacements in battery. An investment is much better than a generator on a financial level.

As for a modest or middle class family, if the choice is made, to ensure his electricity consumption on a 10 KVA group for 4,155 dollars, annual expenses without integrating the cost of externality and maintenance would amount to 6,335.8 dollars, a cost significantly higher than the solar kit of 5 kW capable of providing lighting, appliances and even running a split. With the new technologies available nowadays, mentioned Doty and Turner (Doty & Turner, 2009, p. 11), the energy consumption can be reduced by 50 percent and then comply with lower power solar kit.

Moreover, the photovoltaic systems release no greenhouse gases and guarantee the permanence of the electricity even for days not very sunny. In fact they do not need direct sunlight to produce energy; they just need daylight and this means they can operate even during cloudy and less bright days. Electricity can also be conserved through the bank of batteries. Generators are rather sources of noise and environmental pollution with $CO_2$ emissions whose health effects are harmful with symptoms of intoxication ranging from vertigo, headache, drowsiness, visual disturbances, and a reduction of lucidity and loss of reflexes (Khaled, 2001). Above all, these emissions contribute to global warming (Fanchi & Fanchi, 2013). The choice on solar system is by far the best for the amount of sunshine striking the surface our planet annually provides more than 10,000 times the amount of energy that all of humanity can use in a year (McNermey & Cheek, 2012, p. 49).

## Conclusion

This paper work focused on evaluating the opportunities offered by solar energy in the household electricity consumption model, revealed in many ways the need to integrate this energy source into the energy supply. The analysis helped us to circumscribe the energy deficit in the city of Kinshasa, the capital of the Democratic Republic of Congo, a city whose population growth rate and the influx rate of refugees fleeing wars continues to grow. Data collected from several sources showed that the National Electricity Company, the only company in charge of the production and distribution of electricity, was not able to ensure a permanent supply that matched demand. From the mouths of its leaders only half of the city need estimated at 1,000 MW could be covered by a current yield of 480 to 510 MW hence management marked by rotational load shedding to cover the supply of all municipalities in the city. Faced with this situation, substitution behavior has been developed through the use of power generators to make up for the energy deficit. However, these fuel-powered generators contribute to $CO_2$ emissions that are harmful to health and the environment. An assessment of local potential has allowed us to appreciate the solar potential of the city which would lead to a better use of solar alternatives, the country being in a very high band of sunshine whose values are between 3,250 and 6,000 Watt peak/$m^2$/J for solar energy. Comparing usable solar kits for households, we conclude that solar alternatives would be far better as a solution to the generator set. Despite the relatively high acquisition cost according to the needs of households, meaning US $990 for one kilowatt solar kit capacity and $2,700 for 3 kW solar kit capacity against US $900 for a 4 kW power generator and US $4,155 for 8 kW generator, an annual operational cost reveals a financial benefit of solar kits beyond ecological benefits. An annual operational cost by a poor family gives an envelope of expenses estimated at 1,130 dollars, cost of maintenance and externalities not included against 990 dollars for a solar kit.

For a middle class family, the annual envelope in terms of operating cost is estimated at $6,335.8 for generator use against $4,600 for a solar kit of 5 kW. Even at equal capacity, an 8 kW solar kit that costs $7,500 would be amortized after just under three years at a fuel cost of $3.14 per day to ensure the need for power consumption with a group of 8 kW. In other words, after two and a half years the user of a generator will have reached the investment required for a solar kit that would keep him safe from daily financial expenses and safe from health problems and free of the responsibility of negative externalities over the community.

It is therefore essential to consider awareness campaigns on the merits of adopting solar alternatives as well as to create household support systems to finance the acquisition of solar kits. On the other hand investment facilities in the solar field will have to be supported by government to promote electricity coverage and the social development of communities.

## References


Aantony, F., Durschner, C., & Remmers, K.-H. (2006). *Le photovoltaique pour tous*. Paris, Solarpraxis Berlin: Observ'ER.

ANAPI. (2016). *Investir dans l'Electricité en République Démocratique du Congo.* Kinshasa: Cahier Sectoriel.

Ang, B. W. (1986). *ASEAN energy demand: Trends and structural change.* Singapore: Institute of South East Asian Studies.

Bontems, P., & Rotillon, G. (2013). *L'economie de l'environnement* (4th ed.). Paris (France): Ed. La decouverte.

Doty, S., & Turner, W. C. (2009). *Energy management handbook* (7th ed.). Lilburn, GA: Fairmont Press, Inc.

Evans, R. L. (2007). *Fueling our future. An introduction to sustainable energy.* New York: Cambridge University Press.

Fanchi, J. R., & Fanchi, C. J. (2013). *Energy in the 21st century.* (3rd ed.). Toh Tuck Link, Singapore: World Scientific Publishing.

Gill, P. (2016). *Electrical power equipment maintenance and testing* (2nd ed.). Boca Raton, Florida: CRC Press.

Khaled, Pr N. A. (2001). *Global burden and management of asthma in developing countries.* Bulletin of the World Health Organization, Switzerland.

McNermey, J., & Cheek, M. (2012). *Clean energy nation*. NY: AMACOM.

Moller Andersen, F., Baldini, M., Hansen, L. G., & Jensen, C. L. (2017). Houselholds' hourly electricity consumption and peak demand in Denmark. *Applied Energy, 208,* 607-619.

Rapp, D. (2010). *Solar energy*. Oxford: Oxford University Press, Inc.

University of Colorado. (2006). *The Journal of Energy and Development, 32,* 1-2.